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The Design and Manufacturing of Tablespoon Buckets Pelton Wheel Impulse Turbine

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ABSTRACT
This paper describes the Design and manufacturing of Tablespoon Buckets impulse turbine, a form a Pelton Wheel Impulse Turbine. A Pelton-wheel is a hydro mechanical energy conversion device which converts hydraulic energy of elevated water into mechanical works. It does this by simple impulsion of the jet of water on a series of moving blades called buckets. This mechanical work can be further converted into other forms of energy such as electrical energy by means of an electrical generator. The kinetic energy of the Water-jet is directed tangentially at the buckets of a Pelton-wheel. The Water-jet strikes on each bucket's convex profile and get split into two halves. All the jet energy is used in propelling the rim of the bucket wheel. Invariably, some water jet misses the bucket and passes onto the tail race without doing any useful work. This hydro device is a good source of hydro-electrical energy conversion for a high water head. This project introduces the basic design of Pelton wheel turbine and the working knowledge of Pelton wheel. In the Tablespoon Buckets Pelton wheel, tablespoons are fabricated into buckets. These buckets have elliptical shape which is then attached to the periphery of a rotating wheel. The project discusses the basic design of Tablespoon Buckets Pelton wheel impulse turbine. This includes runner diameter, tablespoon size buckets, the velocity of the wheel (u), the velocity of the jet (v), nozzle diameter, the diameter of wheel, the diameter of the jet, the head of water, and the velocity of the water jet, power and efficiency of the impulse turbine. This Tablespoon Buckets Pelton wheel impulse turbine has a hydraulic efficiency of 97.3% and was produced at the cost of ₦71, 955.00.00.

KEYWORDS: *Tablespoon, Pelton, Wheel, Impulse, Turbine, Power, Generation.*

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I. INTRODUCTION

The Tablespoon Buckets impulse turbine is a form of a Pelton wheel. It is a hydro mechanical energy conversion device that converts hydraulic energy of elevated water into mechanical works; hence it is an axial flow impulse turbine used for high head of water. It is a rotary engine that extracts energy from a fluid flow and converts it into useful mechanical work (Rajput, 2008). The Pelton wheel impulse turbine converts gravitational energy of elevated water into mechanical work. This mechanical work in turn is converted into electrical energy by means of running electrical generator. It is essential to note that, the Pelton wheel is a form of hydraulic turbine that makes use of water for its operation. Considering water as one of the sources of energy, falling water contains stored hydro energy which can be converted to other forms of energy such as mechanical energy for useful work. This is possible since the energy will cause the rotation of a shaft carrying buckets to produce power thereby producing electricity. This Pelton wheel is a tangential flow free jet impulse turbine whose nozzle transforms water under a high head into a powerful jet. In this turbine, all of the kinetic energy of the jet is transformed into mechanical energy, giving rise to a high efficiency of the turbine. This type of free-jet water turbine was first introduced by an American; named Lester Pelton in 1870 and the device is called the Pelton Wheel or Pelton turbine (Rajput, 2008).

Pelton Turbines has been widely used in hydroelectric plants in the northern part of Nigeria example is the kanji dam power generation system. The astonishing resourcefulness of electricity as a source of energy for our industrialised society informed the performance analysis of the Tablespoon Buckets Impulse turbine ascertain the power output of the manufactured mini impulse turbine. This design can also be adopted and applied to rural areas, since small rivers and streams exist within rural areas in Nigeria, most of which maintain a minimum flow all year round. These streams and rivers can be used to develop hydroelectric energy for rural agriculture due to the application of this design concept. Studies confirmed that a great potential of small hydropower can improve on the energy deficits experienced in rural households in Nigeria (Aliyu and Eleagbam, 1990).

Electricity's extraordinary versatility as a source of energy means it can be put to an almost limitless set of applications which include transport, heating, lighting, communications, and consumption, etc. Electrical power is the backbone of modern industrial society, and is expected to remain so for the foreseeable future (Sarab Jyoti, 2013). A turbine is a rotary engine that extracts energy from a fluid flow and converts it into useful mechanical work (Rajput, 2008).

The goal of this work is to design and fabricate a mini impulse type water turbine such as the Pelton wheel to generate mechanical power. The Pelton wheel is a tangential flow free jet impulse turbine. A nozzle transforms water under a high head into a powerful jet. The momentum of this jet is destroyed by striking the runner, which absorbs the resulting force. If the velocity of the water, leaving the runner is nearly zero, all of the kinetic energy of the jet has been transformed into mechanical energy, so the efficiency is high. This type of free-jet water turbine was first introduced by an American; named *Lester Pelton* in 1870 and the device is called the Pelton Wheel or Pelton turbine (Rajput, 2008), which is presented as Figure 1.1.

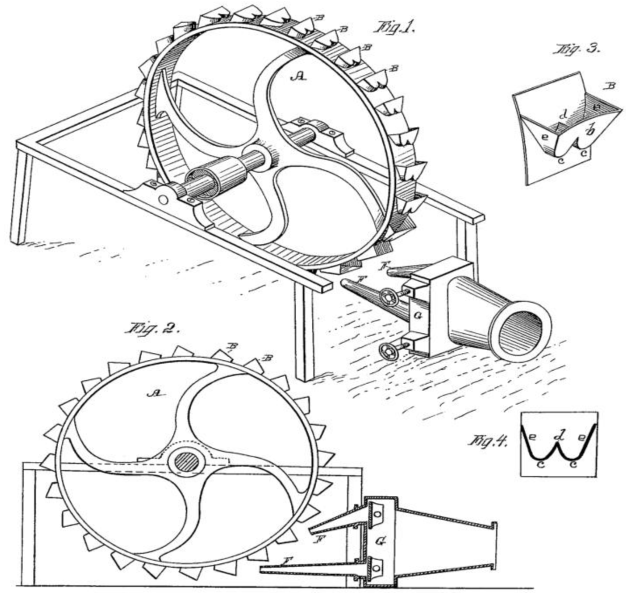

Figure 1.1: First generation Pelton wheel (Allen Pelton 1887)

II. REVIEW OF A PELTON WHEEL

This section presents the background and review of the Pelton wheel which is an Impulse turbine. A review of previous work relating to the designed and has been extensively discussed. The Pelton wheel was first invented by an American inventor, Lester Allen Pelton in 1870s. Shinde1, A. D. and Shelke S. N., 2016 confirm in their study that the dynamic characteristics of a hydro turbine power depend heavily on changes in load disturbances. Thus the hydro turbine exhibits highly nonlinear, non-stationary system whose characteristics varies significantly with the unpredictable load. Nasir, B. A. 2013 design of high efficiency Pelton turbine for micro hydropower plant and obtain a Pelton hydraulic turbine with maximum efficiency during various operating conditions and the turbine parameters such as turbine power, turbine torque, runner diameter, runner length, runner speed, bucket dimensions, number of buckets, nozzle dimension and turbine specific speed were investigated. According to Prajapati1 V. M., Patel, R. H., and Thakkar, K. H 2015, a complete design of impulse turbines has been presented based on theoretical analysis and some empirical relations. The maximum turbine efficiency was found to be 97% constant for different values of head and water flow rate. The complete design parameters such as turbine power, turbine torque, turbine speed, runner dimensions and nozzle dimensions are determined at maximum turbine efficiency using the MATLAB software.

Ishola, A. F. *et al.* 2019 undertook a study, the design and analysis of a Pelton wheel turbine model for a Pico-sized hydropower system powered by rainwater collected on rooftops which is capable of producing the power required for certain functions like charging handsets, mini gadgets and low energy lighting purposes which are very essential in most communities in Nigeria instead of using the generator powered by gasoline which are very costly. Oo, T. Z. *et al.* 2019 carried out a research on the manufacturing of a Pelton turbine that will be capable of generating 220 kW output power from head of 213 m and flow rate of 0.135 m3/s. For these heads and capacity of the turbine, rotational speed is 1000 RPM, specific speed is 18.4, pitch circle diameter is 0.56 m, jet diameter is 0.053 m and nozzle outlet diameter is 0.064 m. The effect of different nozzles, water head and discharge on the performance of THE Pelton turbine system was experimentally investigated by Farge, T. Z *et al. 2017.* The effect of five different nozzles with outlet diameters of (3.61,5.19, 8.87, 12, and 14.8) mm has been studied. They came to the conclusion that for every certain nozzle, decreasing the water head lead to reduction in water discharge and this caused a reduction in the torque, brake power, efficiency and the rotational speed. In addition, the results show that an increase in the nozzle diameter lead to an increase in the discharge and reduction water head. According (Sarab *et al*. 2013), the electrical energy can be put to use in the following area heating, lighting, and communications, among others, noting that electrical power is the backbone of modern industrial society, and is expected to remain so for the foreseeable future. But due to the nature of the energy sector in our country Nigeria faced with challenges such as inadequate power supply due to the high cost of maintenance of its power facilities, poor management systems, and government policies amongst others; there is a need for a mini sustainable means of power generation in a small scale where individuals can depend on for small scale use (Garry and Akata 2002), giving rise to this simplest mini turbine. According to (Sarab, J. K. Nayanmoni G. J., Kalita K. D. 2013) for efficiency of the turbine, in practice, the deflection of jets is limited to about 165^o so that the water leaving a bucket may not hit the back of the following bucket. Hence, the jet angle of the buckets is made as 165^o or 170^o. The goal of this work is to use the impulse type water turbine such as the Tablespoon Buckets Impulse turbine to generate mechanical power, which in turn can produce electrical energy.

III. MATERIALS AND METHODOLOGY

3.1 Materials

The following properties were considered in selecting the materials needed for the construction of the Pelton wheel which include: physical properties, mechanical properties, cost of maintenance, availability of materials, Durability among others. The materials used in the construction of the Pelton wheel were sourced locally, some of the major materials used in the construction are mild steel sheet, mild steel angle iron, stainless steel ladle, bearing set, wooden and mild steel pulley, galvanized shaft, rough and smooth sand paper, welding electrodes, Perspex glass, mild steel runner, pieces of PVC pipes with its fittings, bolt and nuts among others. Table 3.1 shows the part list of the Tablespoon Buckets Impulse Pelton Wheel, while Figure 3.1 shows the exploded view of the Tablespoon Buckets Pelton Wheel.

Table 3.1: Part list of the Tablespoon Buckets Pelton Wheel

S/N	NAME	QUANTITY
1	Casing	1
2	Runner with buckets	1
3	Rotating shaft	1
4	Bearing	2
5	Pulley	2
6	Transmission belt/rope	1
7	Dynamo	1
8	Short pipe	1
9	Control valve	1
10	Pressure gauge	1
11	Elbow joint	4
12	Pump	1
13	Water tank	1
14	Frame	1
15	Nozzle	1

The major parts of the Tablespoon Buckets Pelton wheel impulse turbine, which include the runner with buckets, the water reservoir, the casing, pump unit and the output power unit are assembled together by welding and mechanical fastening using bolts and nuts. The mechanical fastening was to enable an easy assembly and disassembly of each of the parts of the turbine where necessary. The finishing process involves surface smoothening, removal of rough edges, brushing, and painting among others.

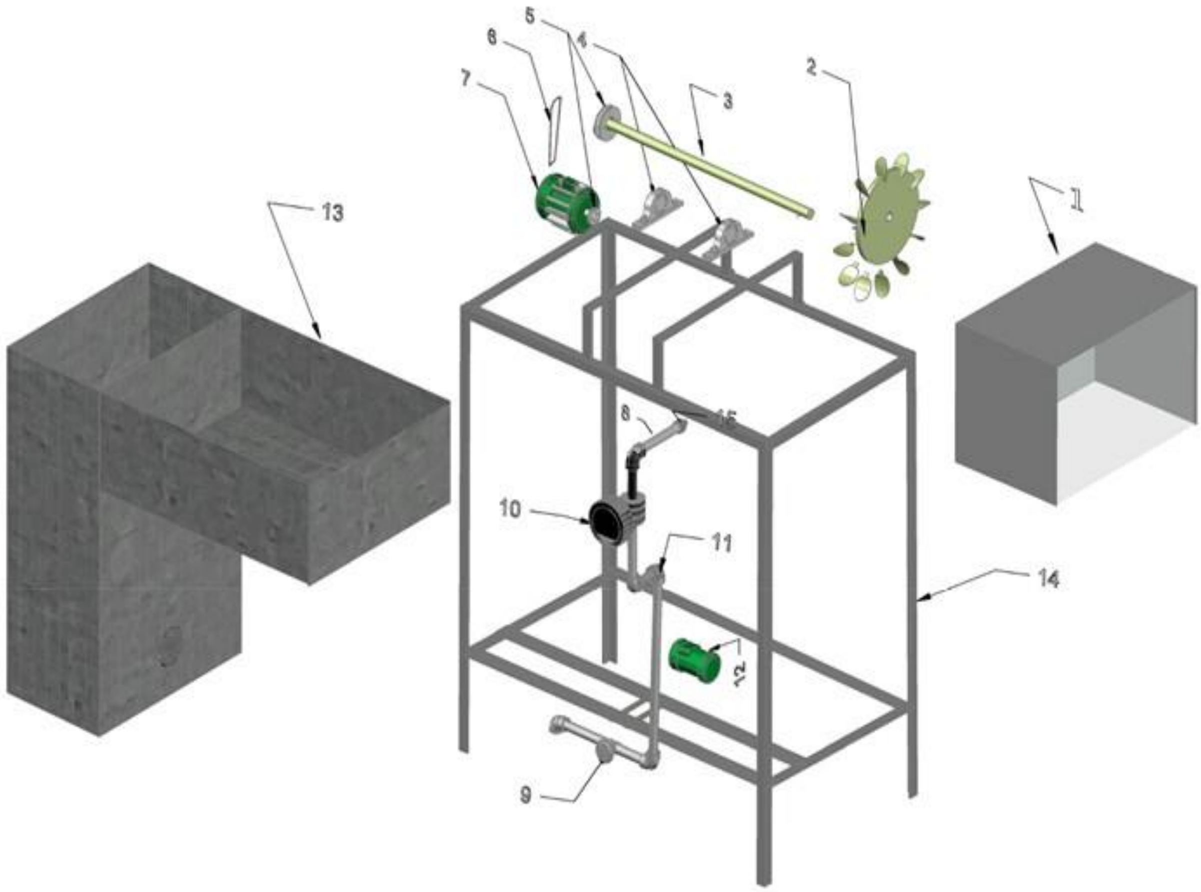

Figure 3.1: The exploded view of the Tablespoon Buckets Pelton Wheel

The Bill of Engineering measurement and evaluation (BEME) was carried out to ascertain the total cost of the materials which was N61, 500.00, as presented in Table 3.2.

Table 3.2: Bill of Engineering Measurement and Evaluation (BEME)

S/N	NAME	MATERIAL	QUANTITY	RATE (₦)	AMOUNT (₦)
1	2mm steel plate	Mild steel	1	18,500	18,500
2	Centrifugal pump (0.5hp)	-	1	10,000	10,000
3	Dc generator	-	1	4,000	4,000
4	Bearing	Mild steel	2	1,500	3,000
5	½” angled bar	Mild steel	2	2,100	4,200
6	Pressure gauge	-	1	6,000	6,000
7	Control valve	PVC	1	500	500
8	¾” round hollow shaft	Galvanized	1	300	300
9	Runner	Mild steel	1	100	100
10	Bucket	Stainless steel	12	130	1,560
11	Pipes	PVC	2	700	800
12	Anti-rust	-	1 tin	800	800
13	Paints	-	2 tins	1,550	3,100
14	Iron filler	-	1 tin	1,500	1,500
15	Sand paper	-	2	200	400
16	Pipe access.	PVC	-	-	500
17	Bolts and nuts	-	-	-	500
18	LED bulbs and others.	-	-	-	800
19	1 inch Perspex glass		1	3,000	3,000
20	Belt housing	Mild steel	1	-	1,000
21	Diverting plate	Aluminum	1	-	300
22	Fan belt	Leather	1	-	800

	TOTAL	**61,500**

Total cost of materials = ₦61, 500

Mobilization = 10% of the total cost of materials = 0.10 × 61,500= ₦ 6150

Contingencies = 2% of the total cost of materials = 0.02 × 61,500= ₦ 1,230

VAT = 5% of the total cost of materials =0.05 × 61,500= ₦ 3,075

Grand total = material cost + Mobilization + Contingencies + VAT = 61,500 + 6150 + 1230 + 3075 = **₦ 71,955**

When the total cost of material is added to mobilization, contingencies and the value added tax on the cost of material, the total cost of producing one Tablespoon Buckets Pelton Wheel turbine was N71,955.00. Figure 3.1 shows the exploded view of the Tablespoon Buckets Pelton Wheel impulse turbine.

3.2 Design Analysis and Fabrication of the Tablespoon Buckets Pelton wheel

The design principle of Pelton wheel (an impulse) turbine was based on the principle of conservation of energy. The hydraulic energy of water is converted to kinetic energy in the nozzle, as the water impinges on the buckets, it loses all its velocity and its energy is converted to mechanical energy in the form of the rotation of the runner. This mechanical energy is used in running an electric generator or dynamo as shown in Figure 3.2, which is directly coupled to the shaft of the hydraulic turbine through transmission belt (Rajput, 2008).

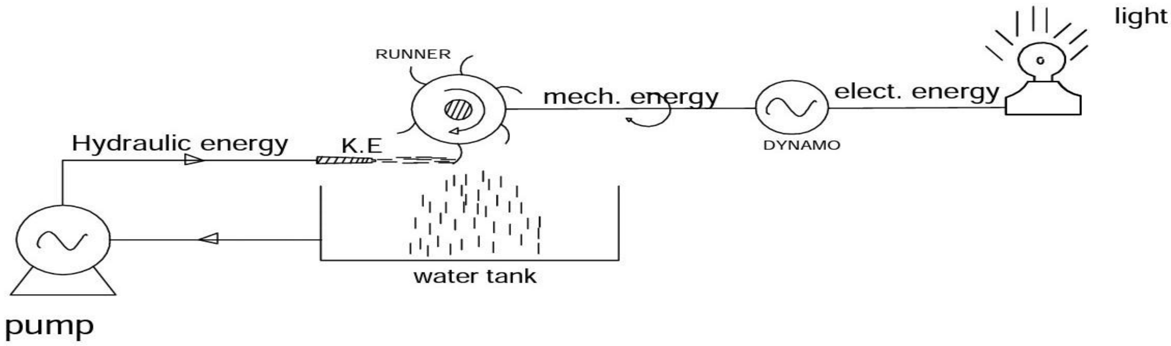

Figure 3.2: Block diagram showing design principle in hydraulic turbine.

The major parts of this Pelton wheel turbine are centrifugal pump, pressure gauge, nozzle, PVC pipe, water tank (tail race), control valve, bucket, casing, runner, shaft, pulley system and bearing set.

3.2 Design Parameters

The following parameters were considered with their usual notation, concepts and formulae for the design and analysis; this includes bucket and a number of buckets, jet ratio, the velocity of the wheel (u), the velocity of the jet (v), speed ratio, specific speed, nozzle diameter, the diameter of the wheel, the diameter of the jet, the head of water, and the velocity of the water jet power and efficiency of the impulse turbine.

3.2.1 Size of Buckets and number of buckets: The Pelton wheel buckets are vital as they receive the water jet and turn the wheel. The number of buckets for a Pelton wheel should be such that the jet is always completely intercepted by the bucket so that volumetric efficiency of the turbine is very close to unity as such, the number of buckets should be few as possible to reduce losses due to friction. The bucket dimension can be determined considering the following concepts according to Rajput (2008) as follows:

The width of the bucket $B = 3 \text{ to } 5d$ 3.1

The length of the bucket $L = 2 \text{ to } 3d$ 3.2

The width of the bucket $W = 1.1d \text{ to } 5mm$ 3.3

The diameter of the bucket $D = 11 \text{ to } 16d$ 3.4

The empirical formula for the number of buckets is as,

$$n = \left(\frac{D}{2d} + 15\right) \quad 3.5$$

where D = Mean bucket diameter and d = Diameter of the jet and B = breadth, L = length, W = width, and D = diameter of the bucket.

3. 2. 2 Diameter of the wheel

The diameter of the wheel is given as,

$$v = \frac{\pi DN}{60} \quad 3.6$$

where v is the peripheral velocity of the wheel

3.2.3 Velocity of the Jet

V is the velocity of the jet given as, $V = C_v\ x\ \sqrt{2gH}$ 3.7

where Cv = coefficient of velocity
g = gravitational constant
H = turbine head

3.2.4 Velocity of wheel (u)

The velocity of the wheel U is given as

$$U = K_u\ x\ \sqrt{2gH} \quad 3.8$$

where U = velocity of the wheel
K_U = speed ratio, given as 0.45

3. 2. 5 Diameter of the Jet

The diameter of the jet is given as,

$$d = \frac{Diameter\ of\ the\ wheel}{10} \quad 3.9$$

3.2.6 Diameter of the Nozzle

The diameter of the nozzle can be derived by equating the total discharge of the wheel to the discharge through the jet. This is presented as,

$$Q = V\ x\ \frac{\pi}{4}\ x\ (d^2) \quad 3.10$$

Therefore, $d = \left(\sqrt[2]{\frac{Q4}{V\pi}}\right)$ 3.11

where d is the diameter of the nozzle.

In this study, nozzle diameter is presented as a function of the control valve opening position in percent (%). The valve positions were divided into four (4) quadrant of 1/4, 1/2, 3/4 and fully open position of the valve; giving 25%, 50%, 75% and 100% opening positions respectively. However, a fifth opening position at 4/5 which is equal to 80% was added to allow for a better understanding of the operations.

3.2.6 Jet ratio (m)

This is defined as the ratio of the pitch diameter (D) of the Pelton wheel to the diameter of the jet (d), given as,

$$m = \frac{D}{d} \quad 3.12$$

3.2.7 Specific speed:

It is the speed of a geometrically similar turbine that would produce unit power under unit head.

$$N_s = \frac{N\sqrt{P}}{H^{\frac{5}{4}}} \quad 3.13$$

3.3 Power and Efficiencies of Pelton wheel

3.3.1 Power produced by impulse turbine

The power produced by an impulse turbine when the jet strikes the buckets can be found using the relationship given below as:

$$P = wQH \quad 3.14$$

Where: w = specific weight of water (9.81kN/m^3)
Q = discharge of the turbine in m^3/sec
H= Head of the turbine

3.3.2 Efficiencies of Pelton wheel

There are three efficiencies employed in an Impulse turbine. These are hydraulic efficiency, mechanical efficiency and the overall efficiency. The overall efficiency is a measure of the performance of a turbine. It is the ratio of actual power produced by the turbine to the energy actually supplied by the turbine as shown in Equation 3.11 and the hydraulic efficiency given in Equation 3.12.

$$\eta_0 = \frac{P}{wQH} \tag{3.15}$$

$$\eta_h = \frac{2(V-u)(1+kCOS\emptyset)u}{V^2} \tag{3.16}$$

where V, u, w, Q, H and P retained their usual nomenclature in the analysis of impulse turbines.

3.2.1 Fabrication and Assembly of part

The fabrication involves the manufacturing of the various parts and finally the parts are then assembled to form the equipment which is now tested to confirm its functionality and performance. Figure 3.3 shows the dimension of different part and section of the turbine. While Figure 3.4 to Figure 3.9 shows the development process of the tablespoon buckets Pelton wheel from the CAD design through to the fabrication, assembling and installation parts, to the finished product. Figures 3.4 and Figure 3.5 are the Isometric drawing of the Front and End views of the Pelton wheel impulse turbine respectively. While from Figure 3.6 shows the fabrication of the runner and the tablespoon buckets, Figure 3.7 to Figure 3.8 indicate the assembling and Installation of parts and Figure 3.9 is the finished Pelton wheel.

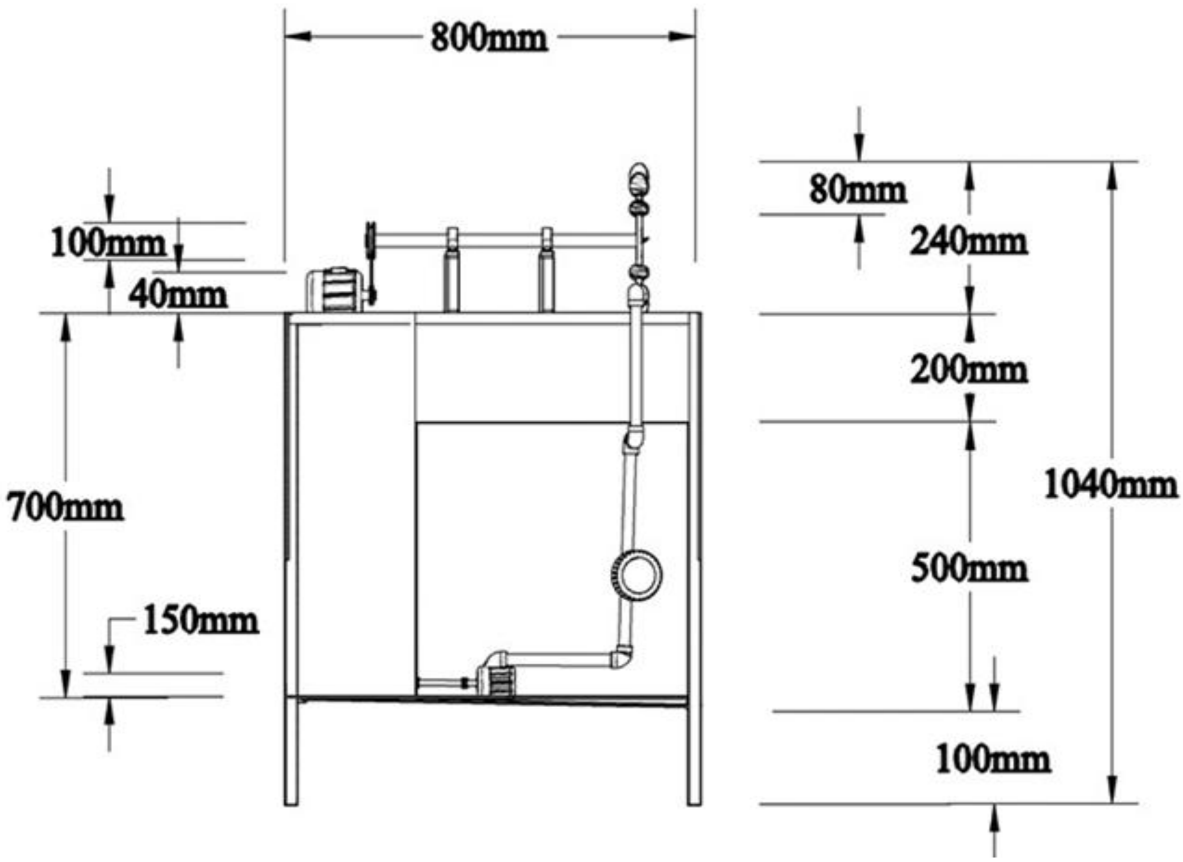

Figure 3.3: Shows the dimension of different part and section of the turbine

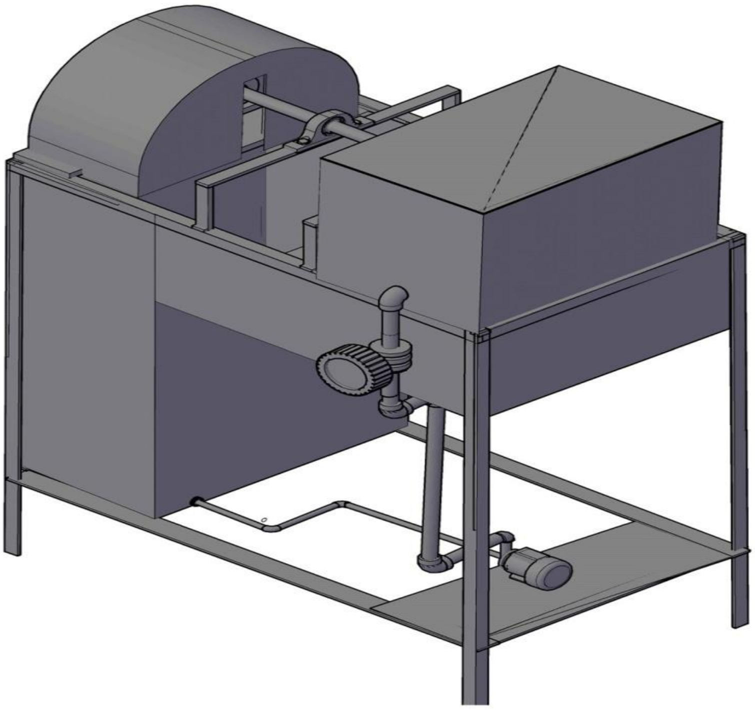

Figure 3.4: (3-D) Isometric drawing of the Front view of the Pelton wheel impulse turbine

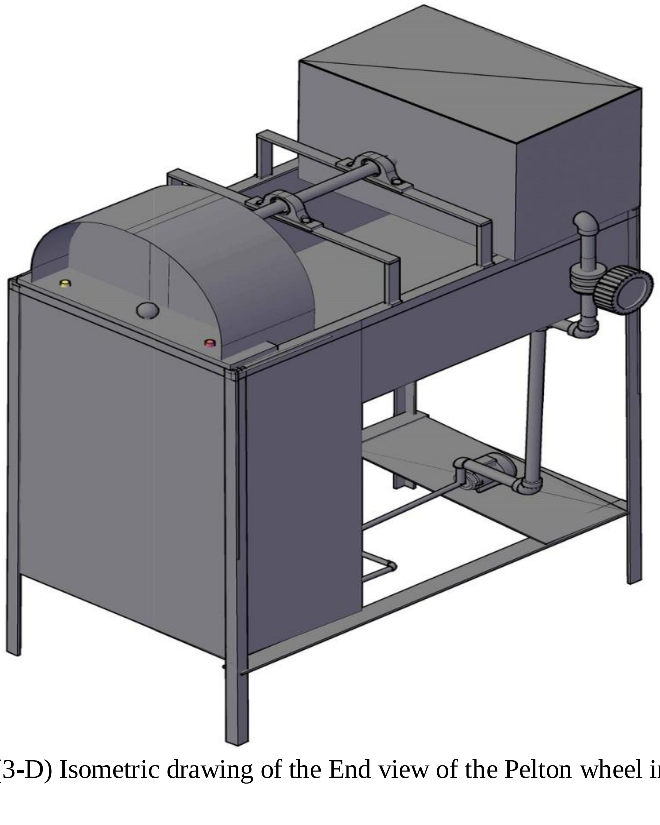

Figure 3.5: (3-D) Isometric drawing of the End view of the Pelton wheel impulse turbine



(a). prepared runner (b). required bucket length (c). ready for joining


(d). prepared wheel manufactured (e). wheel ready for installation

Figure 3.6: Fabrication of the runner and the tablespoon buckets

	
a). 0.5HP water pump	**b). Turbine frame with water tank**

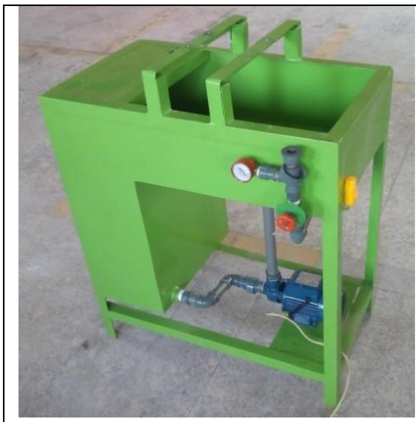	
c) Installation of gauge and pipe network on frame	**d). installation of the wheel**

Figure 3.7: Assembling and Installation of major parts

(a). casing installation **(b). product without belt guide** **(c) Finished Pelton wheel**

Figure 3.8: Assembling and Installation of parts completed

Figure 3.9: The Manufactured Tablespoon Buckets Pelton wheel Impulse Turbine

IV. RESULT AND DISCUSSION

This chapter presents the results and discussion of this work. Section 4.1 discusses the working principle and the operational procedure of the machine, Section 4.2 presents the result; this includes power develop and available, and the hydraulic efficiency of the turbine and 4.3 performance evaluation of the Pelton turbine.

4.1 Working principle of the Pelton wheel

The Pelton turbine is a very good example of the energy converting machine, working on the principles of the conservation of energy. The Pelton wheel turbine consists of a rotor, at the periphery of which is mounted equally spaced hemispherical buckets. Water is transferred from a high head source through the penstock (pipe) which is fitted with a nozzle, through which the water flows out at a high speed jet. A needle spear moving inside the nozzle controls the water flow and at the same time provides a smooth flow with negligible energy loss. All the available potential energy is thus converted into kinetic energy before the jet strikes the buckets of the runner. As the runner rotates, buckets received the water jet, a shaft coupled directly to the runner also rotates due to the mechanical energy, hence, the dynamo attached to the shaft through a pulley belt system rotates thereby converting the mechanical energy to electrical energy (Rajput, 2008).

For safe operation of the pump, it should be ensured that pump is not allowed to run dry before its working fluid is introduced to it in order to prevent damage of the impeller. The power cable should be plugged into a 13amp power source, and the power switch, of the pump turned ON. Due to the centrifugal force of the pump, the working fluid is moved from the tailrace (reservoir), there is an increase in pressure and kinetic energy of the fluid as it is passing through the penstock (conveying pipe). As the fluid gets to the nozzle, the total hydraulic energy of the fluid is converted to kinetic energy. The size and diameter of the water jet going out of the nozzle is dependent on the diameter of the nozzle in this case is constant. As the water jet strikes the turbine bucket by the action of impulse, motion is initiated with constant momentum. The operational procedure of the Pelton wheel is shown as Figure 4.1

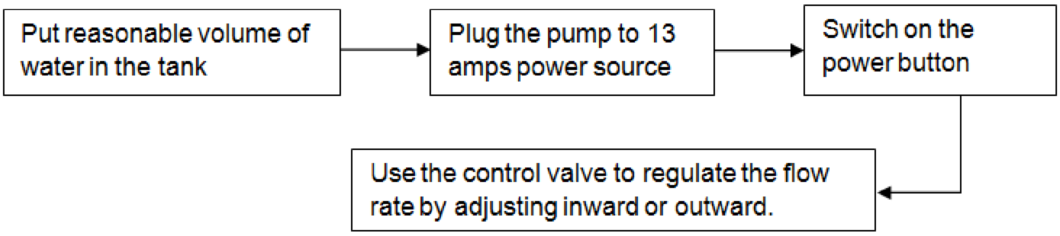

Figure: 4.1: Operational procedures of the Pelton wheel impulse turbine

Torque is initiated on the shaft due to rotary energy of the runner which is converted to mechanical energy. In order to generate electric power, the end of the shaft is provided with a pulley rope system linked to a generator. This is provided to assist the transmission of the rotary power to the generator (dynamo). A bigger capacity of the generator can be employed in order to generate a greater power depending on intending usage.

4.2 Turbine Efficiency

According to Rajput (2008), the hydraulic efficiency (**η_h**) is given as:

$$\eta_h = \frac{2(V-u)(1+kCOS\emptyset)u}{V^2}$$

Where K = blade friction co-efficient which is slightly less unity. When bucket surfaces are perfectly smooth, energy losses due to impact at splitter are neglected and no friction, then k is assumed to be 1, Rajput (2008)
Since the bucket is not semi-circular, the blade angle was measured to be 165°

Blade angle ($\emptyset$) = 165°

Therefore; ϕ =180° − 165° = 15° (Vane angle at outlet)

The following design parameters of the Pelton wheel are employed in this analysis:
Diameter of wheel, D =0.17m
Diameter of jet, d =0.03m
The vane angle of at outlet ϕ =15°
Manufacturer's designed pump head = 35m

$$Velocity\ of\ Jet\ at\ inlet: V_{jet} = C_v\ x\ (\sqrt{2gH})$$

$$V_{jet} = 1.0\ x\ (\sqrt{2\ x\ 9.81\ x\ 35}) = 26.2\ m/s$$

$$Velocity\ of\ wheel: U = k_U\ x\ (\sqrt{2gH})$$

Where k_u = speed ratio given as 0.45

$$U = 0.45\ x\ (\sqrt{2\ x\ 9.81\ x\ 35}) = 11.8\ m/s$$

From; V = velocity of jet = 26.2m/s,
U = velocity of wheel = 11.8m/s
Assuming K=1

$$\eta_h = \frac{2x(26.2-11.8)x(1+COS15^0)x11.8}{26.2^2} = 0.973 = 97.3\%$$

4.3 Performance evaluation of the Tablespoon Buckets Pelton wheel impulse turbine

Performance characteristics of the apparatus were investigated during operation and were analyzed using graphs and charts. These different graphs and charts shows the performance of the machine in terms of efficiency, speed, operating pressures at different range, output power and voltage generated with anticipated constant head. The result obtained was recorded. Table 4.1 shows the operational details of the Pelton wheel with the valve opening position, corresponding discharge against power with a pump head of 35m.

4.3.1 Power available at Nozzle per discharge rate

The power available at the nozzle of the turbine was analysis as presented in Table 4.2 and a graph of discharge against power available at the nozzle was plotted as shown in Figure 4.1.

Table 4. 1: Shows valve opening position, corresponding discharge against power

S/N	Valve control opening position	Position in Percent (%)	Discharge (Q) m^3/s	Power (W)
1	Valve fully closed	0%	0	0
2	Valve open at $\frac{1}{4}$	25%	0.00004	13.36
3	Valve open at $\frac{1}{2}$	50%	0.00007333	24.50
4	Valve open at $\frac{3}{4}$	75%	0.0001133	37.85
5	Valve open at $\frac{4}{5}$	80%	0.00012	40.10
6	Valve fully opened	100%	0.0001433	47.87

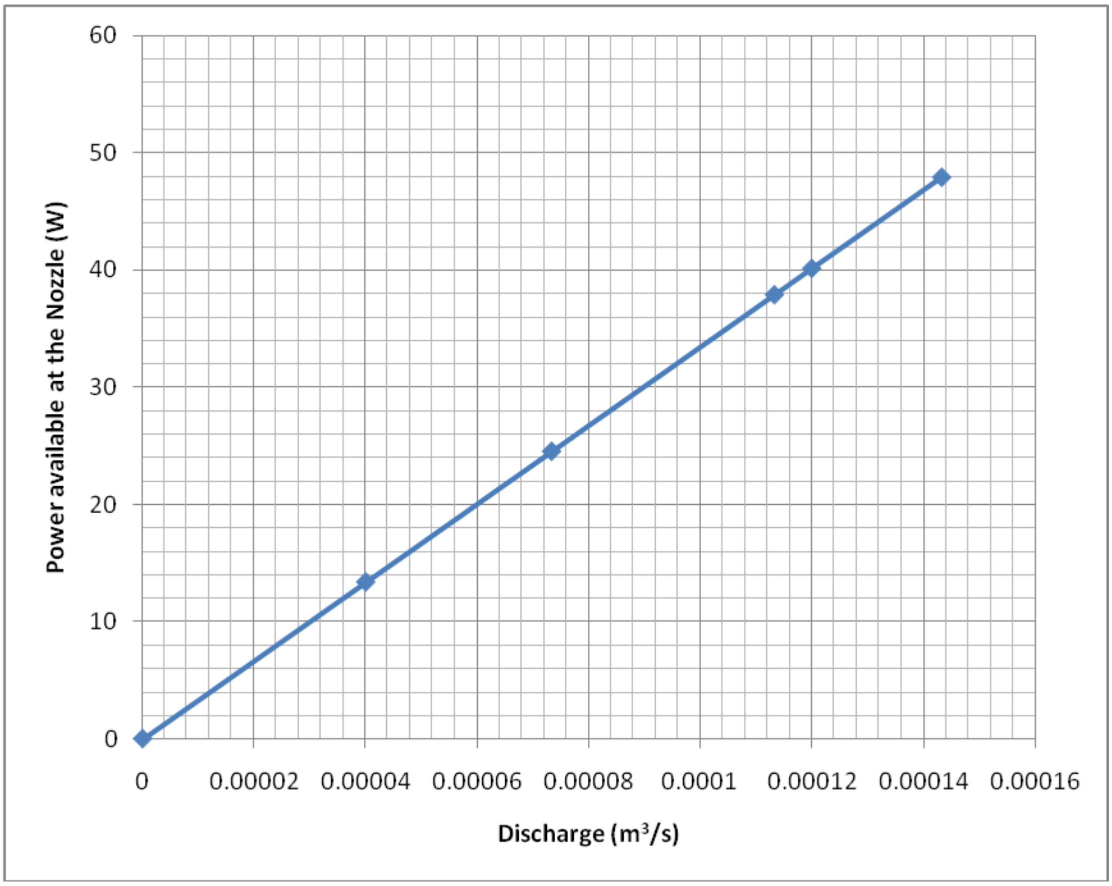

Figure: 4.1: Graph of power available at the nozzle against discharge of the turbine (Ekong, G.I. 2020)

Finally, the fabrication Pelton wheel cost N71, 955.00 as compared to the ones in the market, which is between ₦ 200, 000.00 - ₦ 250, 000.00 with an efficiency of 97.3%. The size is comparatively small and it is easy to assemble and disassembled to ease mobility, doesn't much occupy space and hence, the cost of maintenances is low.

V. CONCLUSION

A Tablespoon Buckets Pelton wheel Impulse turbine with a hydraulic efficiency of 97.3% at the cost of ₦71, 955.00 capable of producing 47.87W power has been produced. The analysis shows that adjusting the valve position outward increases the discharge from the turbine, which correspondingly increases the power and efficiency of the turbine. The manufactured turbine is easy to assemble and disassembled. The hydraulic efficiency of this Tablespoon Buckets impulse turbine is in good agreement with the standard Rajput (2008) experiment. The analysis indicates that the cost will reduce remarkably when compared to the market value of a similar turbine if mass produced due to bulk purchased of materials.

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